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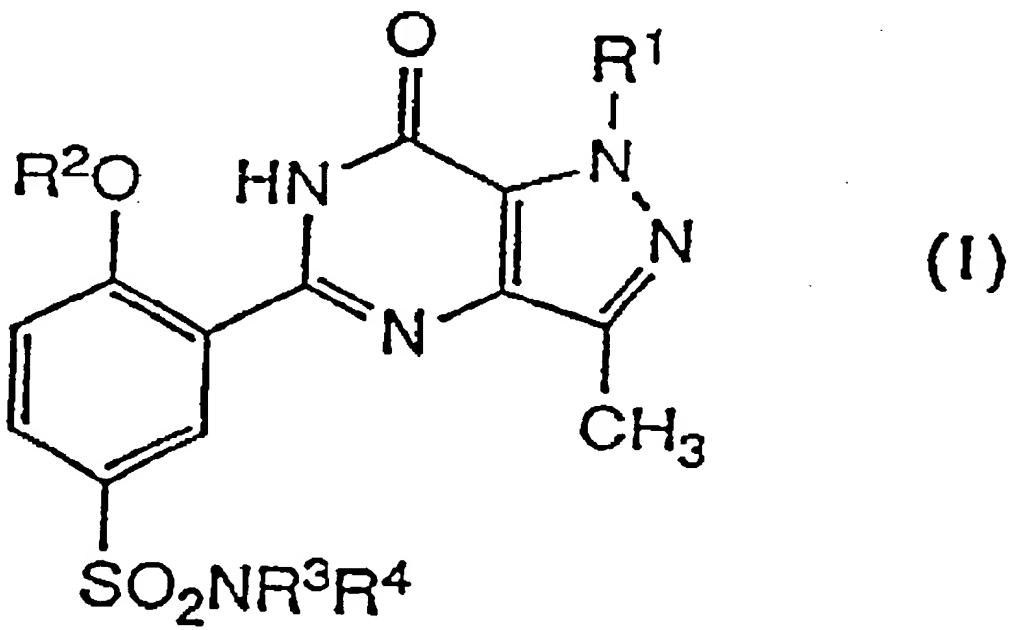
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(54) Title: BICYCLIC HETEROCYCLIC COMPOUNDS FOR THE TREATMENT OF IMPOTENCE



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(57) Abrégé/Abstract:

The use of certain 5-arylpyrazolo[4,3-d]pyrimidin-7-ones, 6-arylpyrazolo[3,4-d]pyrimidin-4-ones, 2-arylquinazolin-4-ones, 2-arylpurin-6-ones and 2-arylpyrido[3,2-d]pyrimidin-4-ones, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man; a pharmaceutical composition for said treatment; and a method of said treatment of said animal with said pharmaceutical composition or with said either entity.

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(54) Title: BICYCLIC HETEROCYCLIC COMPOUNDS FOR THE TREATMENT OF IMPOTENCE

(57) Abstract

The use of certain 5-arylpyrazolo[4,3-d]pyrimidin-7-ones, 6-arylpyrazolo[3,4-d]pyrimidin-4-ones, 2-arylquinazolin-4-ones, 2-arylpurin-6-ones and 2-arylpyrido[3,2-d]pyrimidin-4-ones, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man; a pharmaceutical composition for said treatment; and a method of said treatment of said animal with said pharmaceutical composition or with said either entity.

BICYCLIC HETEROCYCLIC COMPOUNDS FOR
THE TREATMENT OF IMPOTENCE

This invention relates to the use of certain pyrazolo[4,3-d]pyrimidin-7-ones, pyrazolo[3,4-d]pyrimidin-4-ones, quinazolin-4-ones, purin-6-ones and pyrido[3,2-d]pyrimidin-4-ones for the treatment of impotence.

Impotence can be defined literally as a lack of power, in the male, to copulate and may involve an inability to achieve penile erection or ejaculation, or both. More specifically, erectile impotence or dysfunction may be defined as an inability to obtain or sustain an erection adequate for intercourse. Its prevalence is claimed to be between 2 and 7% of the human male population, increasing with age, up to 50 years, and between 18 and 75% between 55 and 80 years of age. In the USA alone, for example, it has been estimated that there are up to 10 million impotent males, with the majority suffering from problems of organic rather than of psychogenic origin.

Reports of well-controlled clinical trials in man are few and the efficacy of orally administered drugs is low. Although many different drugs have been shown to induce penile erection, they are only effective after direct injection into the penis, e.g. intraurethrally or intracavernosally (i.c.), and are not approved for erectile dysfunction. Current medical treatment is based on the i.c. injection of vasoactive substances and good results have been claimed with phenoxybenzamine, phentolamine, papaverine and prostaglandin E₁, either alone or in combination; however, pain, priapism and fibrosis of the penis are associated with the i.c. administration of some of these agents. Potassium channel openers (KCO) and vasoactive intestinal polypeptide (VIP) have also been shown to be active i.c., but cost and stability issues could limit development of the latter. An alternative

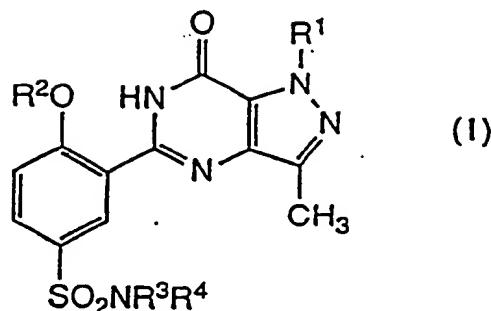
to the i.c. route is the use of glyceryl trinitrate (GTN) patches applied to the penis, which has been shown to be effective but produces side-effects in both patient and partner.

As a general alternative to pharmacological intervention, a variety of penile prostheses has been used to assist achievement of an erection. The short term success rate is good, but problems with infection and ischaemia, especially in diabetic men, make this type of treatment a final option rather than first-line therapy.

The compounds of the invention are potent inhibitors of cyclic guanosine 3',5'-monophosphate phosphodiesterases (cGMP PDEs) in contrast to their inhibition of cyclic adenosine 3',5'-monophosphate phosphodiesterases (cAMP PDEs). This selective enzyme inhibition leads to elevated cGMP levels which, in turn, provides the basis for the utilities already disclosed for the said compounds in WO-A-93/06104, WO-A-93/07149, WO-A-93/12095, WO-A-94/00453 and WO-A-94/05661 respectively, namely in the treatment of stable, unstable and variant (Prinzmetal) angina, hypertension, pulmonary hypertension, congestive heart failure, atherosclerosis, conditions of reduced blood vessel patency e.g. post-percutaneous transluminal coronary angioplasty (post-PTCA), peripheral vascular disease, stroke, bronchitis, allergic asthma, chronic asthma, allergic rhinitis, glaucoma, and diseases characterised by disorders of gut motility, e.g. irritable bowel syndrome (IBS).

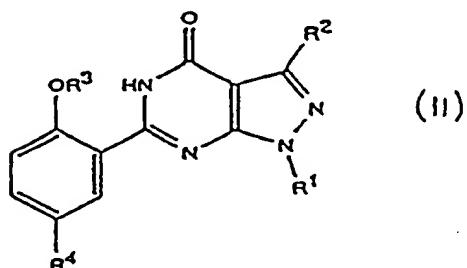
Unexpectedly, it has now been found that these disclosed compounds are useful in the treatment of erectile dysfunction. Furthermore the compounds may be administered orally, thereby obviating the disadvantages associated with i.c. administration. Thus the present invention concerns the use of a compound of formula (I):

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wherein R^1 is methyl or ethyl;
 R^2 is ethyl or n-propyl;
and R^3 and R^4 are each independently H, or $\text{C}_1\text{-C}_6$ alkyl optionally substituted with $\text{C}_5\text{-C}_7$ cycloalkyl or with morpholino;

a compound of formula (II):



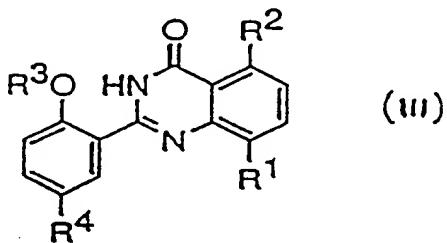
wherein R^1 is $\text{C}_1\text{-C}_6$ alkyl;
 R^2 is H; methyl or ethyl;
 R^3 is $\text{C}_2\text{-C}_4$ alkyl;
 R^4 is H; $\text{C}_1\text{-C}_4$ alkyl optionally substituted with NR^5R^6 , CN, CONR^5R^6 or CO_2R^7 ; $\text{C}_2\text{-C}_4$ alkenyl optionally substituted with CN, CONR^5R^6 or CO_2R^7 ; $\text{C}_2\text{-C}_4$ alkanoyl optionally substituted with NR^5R^6 ; $\text{SO}_2\text{NR}^5\text{R}^6$; CONR^5R^6 ; CO_2R^7 or halo;
 R^5 and R^6 are each independently H or $\text{C}_1\text{-C}_4$

alkyl; or, together with the nitrogen atom to which they are attached, form a pyrrolidino, piperidino, morpholino, 4-(NR⁸)-1-piperazinyl or 1-imidazolyl group wherein said group is optionally substituted with one or two C₁-C₄ alkyl groups;

R⁷ is H or C₁-C₄ alkyl;

and R⁸ is H; C₁-C₃ alkyl or (hydroxy)C₂-C₃ alkyl;

a compound of formula (III):



wherein R¹ is H; C₁-C₄ alkyl; C₁-C₄ alkoxy or CONR⁵R⁶;
 R² is H or C₁-C₄ alkyl;
 R³ is C₂-C₄ alkyl;
 R⁴ is H; C₂-C₄ alkanoyl optionally substituted with NR⁷R⁸; (hydroxy)C₂-C₄ alkyl optionally substituted with NR⁷R⁸; CH=CHCO₂R⁹;
 CH=CHCONR⁷R⁸; CH₂CH₂CO₂R⁹; CH₂CH₂CONR⁷R⁸;
 SO₂NR⁷R⁸; SO₂NH(CH₂)_nNR⁷R⁸ or imidazolyl;
 R⁵ and R⁶ are each independently H or C₁-C₄ alkyl;
 R⁷ and R⁸ are each independently H or C₁-C₄ alkyl; or, together with the nitrogen atom to which they are attached, form a pyrrolidino, piperidino, morpholino or 4-(NR¹⁰)-1-piperazinyl group wherein any

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of said groups is optionally substituted with CONR⁵R⁶;

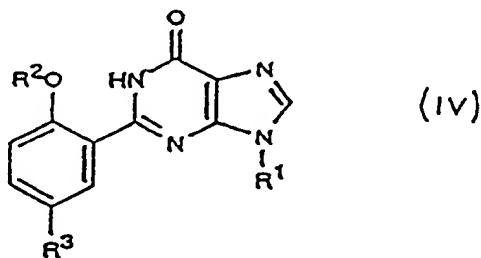
R⁹ is H or C₁-C₄ alkyl;

R¹⁰ is H; C₁-C₃ alkyl or (hydroxy)C₂-C₃ alkyl;

and n is 2, 3 or 4;

with the proviso that R⁴ is not H when R¹ is H, C₁-C₄ alkyl or C₁-C₄ alkoxy;

a compound of formula (IV):



wherein R¹ is C₁-C₄ alkyl;

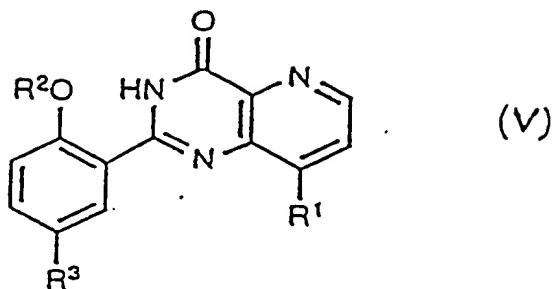
R² is C₂-C₄ alkyl;

R³ is H or SO₂NR⁴R⁵;

R⁴ and R⁵ together with the nitrogen atom to which they are attached form a pyrrolidino, piperidino, morpholino or 4-(NR⁶)-1-piperazinyl group;

and R⁶ is H or C₁-C₃ alkyl;

or a compound of formula (V):



wherein R¹ is H; C₁-C₄ alkyl; CN or CONR⁴R⁵;
 R² is C₂-C₄ alkyl;
 R³ is SO₂NR⁶R⁷; NO₂; NH₂; NHCOR⁸; NHSO₂R⁸ or
 N(SO₂R⁸)₂;
 R⁴ and R⁵ are each independently selected from H and C₁-C₄ alkyl;
 R⁶ and R⁷ are each independently selected from H and C₁-C₄ alkyl optionally substituted with CO₂R⁹, OH, pyridyl, 5-isoxazolin-3-onyl, morpholino or 1-imidazolidin-2-onyl; or, together with the nitrogen atom to which they are attached, form a pyrrolidino, piperidino, morpholino, 1-pyrazolyl or 4-(NR¹⁰)-1-piperazinyl group wherein any of said groups may optionally be substituted with one or two substituents selected from C₁-C₄ alkyl, CO₂R⁹, NH₂ and OH;
 R⁸ is C₁-C₄ alkyl or pyridyl;
 R⁹ is H or C₁-C₄ alkyl;
 and R¹⁰ is H; C₁-C₄ alkyl or (hydroxy)C₂-C₃ alkyl;
 or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of erectile dysfunction in a

male animal, including man.

The invention also provides a commercial package comprising a compound of formula (I), (II), (III), (IV) or (V) as described above, or a pharmaceutically acceptable salt thereof, together with instructions for its use in the curative or prophylactic treatment of erectile dysfunction or female sexual dysfunction, premature labor or dysmenorrhea.

In the above definition, unless otherwise indicated, alkyl and alkoxy groups having three or more carbon atoms, and 10 alkenyl and alkanoyl groups having four carbon atoms, may be straight chain or branched chain. Halo means fluoro, chloro, bromo or iodo.

The compounds of the invention may contain one or more asymmetric centres and thus they can exist as enantiomers 15 or diastereoisomers. Furthermore, certain compounds of formulae (II) and (III) which contain alkenyl groups may exist as cis-isomers or trans-isomers. In each instance, the invention includes both mixtures and separate individual isomers.

20 The compounds of the invention may also exist in tautomeric forms and the invention includes both mixtures and separate individual tautomers.

The pharmaceutically acceptable salts of the compounds of the invention which contain a basic centre are, 25 for example, non-toxic acid addition salts formed with inorganic acids such as hydrochloric, hydrobromic, sulphuric and phosphoric acid, with organo-sulphonic acids. The compounds of the invention can also provide pharmaceutically acceptable metal salts, in particular non-toxic alkali metal 30 salts, with bases. Examples include the sodium and potassium salts. For a review on suitable pharmaceutical salts, see J. Pharm. Sci., 1977, 66, 1.

A preferred group of compounds is that of formula (I) wherein R₃ is H; methyl or ethyl; R⁴ is C₁₋₆ alkyl optionally substituted with cyclohexyl or with morpholino; and R¹ and R² are as previously defined for formula (I); of formula (II) 5 wherein R¹ is n-propyl; R² is H or methyl; R³ is ethyl or n-propyl; R⁴ is H; ethyl substituted with CONR⁵R⁶ or CO₂R⁷; vinyl substituted with CONR⁵R⁶ or CO₂R⁷; acetyl substituted with NR⁵R⁶; SO₂NR⁵R⁶; CO₂R⁷ or bromo; R⁵ and R⁶

together with the nitrogen atom to which they are attached form a morpholino, 4-(NR⁸)-1-piperazinyl or 2,4-dimethyl-1-imidazolyl group; R⁷ is H or t-butyl; and R⁸ is methyl or 2-hydroxyethyl; of formula (III) wherein R¹ is H; methyl; methoxy or CONR⁵R⁶; R² is H or methyl; R³ is ethyl or n-propyl; R⁴ is H; acetyl optionally substituted with NR⁷R⁸; hydroxyethyl substituted with NR⁷R⁸; CH=CHCO₂R⁹; CH=CHCONR⁷R⁸; CH₂CH₂CO₂R⁹; SO₂NR⁷R⁸; SO₂NH(CH₂)₃NR⁷R⁸ or 1-imidazolyl; R⁵ and R⁶ are each independently H or ethyl; R⁷ and R⁸ together with the nitrogen atom to which they are attached form a piperidino, 4-carbamoylpiperidino, morpholino or 4-(NR¹⁰)-1-piperazinyl group; R⁹ is H or t-butyl; and R¹⁰ is H; methyl or 2-hydroxyethyl; with the proviso that R⁴ is not H when R¹ is H, methyl or methoxy; of formula (IV) wherein R¹ and R² are each independently ethyl or n-propyl; R⁴ and R⁵ together with the nitrogen atom to which they are attached form a 4-(NR⁶)-1-piperazinyl group; and R³ and R⁶ are as previously defined for formula (IV); and of formula (V) wherein R¹ is H; n-propyl; CN or CONH₂; R² is ethyl; R³ is SO₂NR⁶R⁷; NO₂; NH₂; NHCOCH(CH₃)₂; NHSO₂CH(CH₃)₂; NHSO₂(3-pyridyl) or N[SO₂(3-pyridyl)]₂; R⁶ is H; methyl or 2-hydroxyethyl; R⁷ is methyl optionally substituted with 2-pyridyl or 5-isoxazolin-3-onyl; or ethyl 2-substituted with OH, CO₂CH₂CH₃, morpholino or 1-imidazolidin-2-onyl; or R⁶ and R⁷ together with the nitrogen atom to which they are attached form a (4-CO₂R⁹)piperidino, 5-amino-3-hydroxy-1-pyrazolyl or 4-(NR¹⁰)-1-piperazinyl group; R⁹ is H or ethyl; and R¹⁰ is H; methyl or 2-hydroxyethyl.

A particularly preferred group of compounds is that of formula (III) wherein R¹ is methyl; CONH₂ or CONHCH₂CH₃; R² is H; R³ is ethyl or n-propyl; R⁴ is H; acetyl; 1-hydroxy-2-(NR⁷R⁸)ethyl; CH=CHCO₂C(CH₃)₃; CH=CHCONR⁷R⁸; SO₂NR⁷R⁸ or 1-imidazolyl; R⁷ and R⁸

together with the nitrogen atom to which they are attached form a 4-(NR¹⁰)-1-piperazinyl group; and R¹⁰ is methyl or 2-hydroxyethyl; with the proviso that R⁴ is not H when R¹ is methyl; of formula (IV) wherein R¹ is n-propyl; R² is ethyl; and R³ is 1-piperazinylsulphonyl or 4-methyl-1-piperazinylsulphonyl; and of formula (V) wherein R¹ is n-propyl or CN; R² is ethyl; R³ is SO₂NR⁶R⁷; NHSO₂CH(CH₃)₂; NHSO₂(3-pyridyl) or N[SO₂(3-pyridyl)]₂; R⁶ is H or methyl; R⁷ is methyl; or ethyl 2-substituted with CO₂CH₂CH₃; morpholino or 1-imidazolidin-2-onyl; or R⁶ and R⁷ together with the nitrogen atom to which they are attached form a (4-CO₂R⁹)piperidino or 4-(NR¹⁰)-1-piperazinyl group; R⁹ is H or ethyl; and R¹⁰ is H; methyl or 2-hydroxyethyl.

Especially preferred individual compounds of the invention include:

1-ethyl-5-[5-(n-hexylsulphamoyl)-2-n-propoxyphenyl]-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

1-ethyl-5-(5-diethylsulphamoyl-2-n-propoxyphenyl)-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[5-(N-cyclohexylmethyl-N-methylsulphamoyl)-2-n-propoxyphenyl]-1-ethyl-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

6-(5-bromo-2-n-propoxyphenyl)-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

3-methyl-6-(5-morpholinosulphonyl-2-n-propoxyphenyl)-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

6-[5-(2-carboxyvinyl)-2-n-propoxyphenyl]-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

6-[5-(2-t-butoxycarbonylvinyl)-2-n-propoxyphenyl]-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

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3-methyl-6-[5-(2-morpholinocarbonylvinyl)-2-n-propoxyphenyl]-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

3-methyl-6-[5-(2-morpholinocarbonylethyl)-2-n-propoxyphenyl]-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}-8-methylquinazolin-4(3H)-one;

2-{5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]-2-n-propoxyphenyl}-8-methylquinazolin-4(3H)-one;

8-methyl-2-{5-[2-(4-methyl-1-piperazinylcarbonyl)-ethenyl]-2-n-propoxyphenyl}quinazolin-4(3H)-one;

8-carbamoyl-2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}quinazolin-4(3H)-one;

8-ethylcarbamoyl-2-(2-n-propoxyphenyl)quinazolin-4(3H)-one;

2-[2-ethoxy-5-(4-ethoxycarbonylpiperidino-sulphonyl)phenyl]-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

2-[5-(4-carboxypiperidinosulphonyl)-2-ethoxyphenyl]-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

and 2-{2-ethoxy-5-[(bis-3-pyridylsulphonyl)amino]-phenyl}-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one.

The compounds of formulae (I), (II), (III), (IV) and (V) and their pharmaceutically acceptable salts, processes for the preparation thereof, in vitro test methods for determining the cGMP PDE and cAMP PDE inhibitory activities thereof, pharmaceutical compositions thereof and routes of administration for human use, are described in WO-A-93/06104, WO-A-93/07149, WO-A-93/12095, WO-A-94/00453 and WO-A-94/05661 respectively.

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A preliminary investigation was carried out with a view to isolating and characterising the cyclic nucleotide PDEs of human corpus cavernosum, relaxation of which leads to penile erection. Studies of substrate specificity, response to activators and inhibitor sensitivity, have demonstrated that human corpus cavernosum contains three distinct PDE enzymes.

Methods

Fresh frozen human penis was obtained from IIMM (Pennsylvania). Tissue was thawed at room temperature, 10 the corpus cavernosum was dissected from the penis to yield approximately 2-4 g of tissue and the following isolation protocol was followed. Tissue was coarsely chopped in ice-cold isotonic buffer (35 ml) containing 15 250mM sucrose, 1mM EDTA, 0.5mM PMSF and 20mM HEPES, pH 7.2, and the mixture subjected to brief (1 min.) treatment with a Silversen mixer/emulsifier. Homogenates were prepared using homogeniser tubes with teflon pestles and soluble fraction was prepared by 20 centrifugation at 100,000 x g for 60 min. at 4°C. 10 ml of high speed supernatant was applied to a Pharmacia Mono Q anion exchange column (1 ml bed volume) equilibrated with buffer containing 1mM EDTA, 0.5 mM 25 PMSF and 20mM HEPES, pH 7.2 (chromatography buffer). The column was then washed with 5 bed volumes of chromatography buffer, after which PDEs were eluted using a continuous gradient of 0-500mM NaCl (total volume 35 ml) and 1 ml fractions collected.

Column fractions were assayed for PDE activity 30 using 500nM cGMP or 500nM cAMP as substrate. cAMP PDE activity was also determined in the presence of 1 μ M unlabelled cGMP and the PDE activity of selected fractions was determined in the presence of 10mM CaCl₂ and 10 units/ml 35 bovine brain calmodulin. Appropriate fractions were pooled and stored at 4°C during the

course of the study.

Inhibition studies were performed using a substrate concentration of 500nM throughout. All inhibitors were dissolved in DMSO and concentration-response curves were constructed over the range 3×10^{-10} to 1×10^{-4} M in half log increments. IC₅₀ values were calculated using the sigmoidal curve fitting algorithm of biostat.

Results

Human corpus cavernosum soluble PDEs were separated into three distinct fractions of activity. The first, fraction I, (designated by order of elution) represents the major PDE present and is highly selective for cGMP as substrate. This fraction was found to be insensitive to stimulation by calcium/calmodulin and was classified as PDE_V. Fraction II hydrolyses cGMP and cAMP, with the latter activity being stimulated in the presence of cGMP, and is classified as PDE_{II}, whilst fraction III is cAMP selective and this activity is inhibited in the presence of cGMP, consistent with PDE_{III} activity.

In order to further characterise the PDE isoenzymes present in the tissue, studies were performed using a variety of inhibitors. Inhibitor studies with fractions I and II were performed using cGMP as substrate, whilst fraction III studies utilised cAMP. These studies confirmed that fraction I corresponds to PDE_V, whilst fraction III was clearly identified as PDE_{III}; fraction II (PDE_{II}) was relatively insensitive to all the inhibitors tested.

In summary, the above investigation identified three PDE isoenzymes in human corpus cavernosum tissue. The predominant PDE is the cGMP-specific PDE_V, whilst cGMP-stimulated cAMP PDE_{II} and cGMP-inhibited cAMP PDE_{III}

are also present.

Certain compounds of the invention have been tested in vitro and found to be potent and selective inhibitors of the cGMP-specific PDE_v. Thus relaxation of the corpus cavernosum tissue and consequent penile erection is presumably mediated by elevation of cGMP levels in the said tissue, by virtue of the PDE inhibitory profile of the compounds of the invention.

Although the compounds of the invention are envisaged primarily for the treatment of erectile dysfunction or male sexual dysfunction, they may also be useful for the treatment of female sexual dysfunction, including orgasmic dysfunction related to clitoral disturbances, and of premature labour and dysmenorrhea.

Generally, in man, oral administration of the compounds of the invention is the preferred route, being the most convenient and avoiding the disadvantages associated with i.c. administration. A preferred dosing regimen for a typical man is 5 to 75 mg of compound three times daily. In circumstances where the recipient suffers from a swallowing disorder or from impairment of drug absorption after oral administration, the drug may be administered parenterally, e.g. sublingually or buccally.

For veterinary use, a compound of the invention or a non-toxic salt thereof is administered as a suitably acceptable formulation in accordance with normal veterinary practice and the veterinary surgeon will determine the dosing regimen and route of administration which will be most appropriate for a particular male animal.

Thus the invention includes a pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising a compound of formula (I), (II), (III), (IV) or (V), or a pharmaceutically acceptable salt

thereof, together with a pharmaceutically acceptable diluent or carrier.

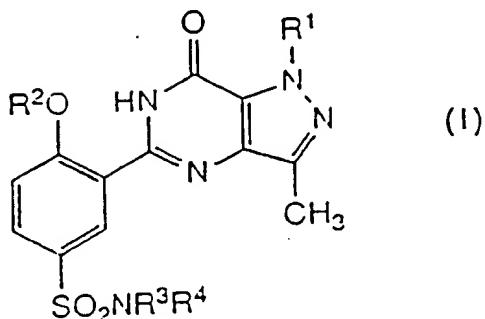
There is further provided a process for the preparation of a pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising formulating a compound of formula (I), (II), (III), (IV) or (V), or a pharmaceutically acceptable salt thereof, with a pharmaceutically acceptable diluent or carrier.

The invention also provides a method of treating a male animal, including man, to cure or prevent erectile dysfunction which comprises treating said male animal with an effective amount of a compound of formula (I), (II), (III), (IV) or (V), or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity.

CLAIMS:

1. The use of a compound of formula (I):

5'



(I)

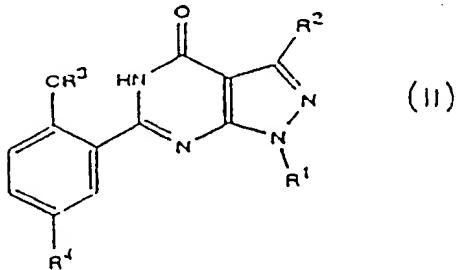
wherein R^1 is methyl or ethyl;

R^2 is ethyl or n-propyl; and

10 R^3 and R^4 are each independently H, or $\text{C}_1\text{-C}_6$ alkyl unsubstituted or substituted with $\text{C}_5\text{-C}_7$ cycloalkyl or with morpholino;

a compound of formula (II);

15



(II)

wherein R^1 is $\text{C}_1\text{-C}_6$ alkyl;

R^2 is H; methyl or ethyl;

R^3 is $\text{C}_2\text{-C}_4$ alkyl;

20

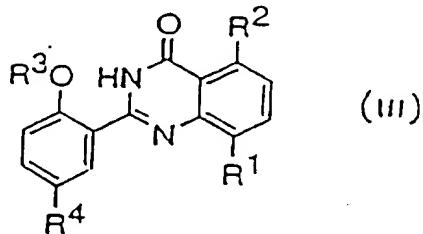
R^4 is H; $\text{C}_1\text{-C}_4$ alkyl unsubstituted or substituted with NR^5R^6 , CN , CONR^5R^6 or CO_2R^7 ; $\text{C}_2\text{-C}_4$ alkenyl optionally substituted with CN , CONR^5R^6 or CO_2R^7 ;

C₂-C₄ alkanoyl unsubstituted or substituted with SO₂NR⁵R⁶; CONR⁵R⁶; CO₂R⁷ or halo;

5 R⁵ and R⁶ are each independently H or C₁-C₄ alkyl; or together with the nitrogen atom to which they are attached, form a pyrrolidino, piperidino, morpholino, 4-(NR⁸)-1-piperazinyl or 1-imidazolyl group wherein said group is unsubstituted or substituted with one or two C₁-C₄ alkyl groups;

10 R⁷ is H or C₁-C₄ alkyl; and

R⁸ is H; C₁-C₃ alkyl or (hydroxy)C₂-C₃ alkyl;
a compound of formula (III):



15 wherein R¹ is H; C₁-C₄ alkyl; C₁-C₄ alkoxy or CONR⁵R⁶;

R² is H or C₁-C₄ alkyl;

R³ is C₂-C₄ alkyl;

20 R⁴ is H; C₂-C₄ alkanoyl unsubstituted or substituted with NR⁷R⁸; (hydroxy)C₂-C₄ alkyl unsubstituted or substituted with NR⁷R⁸; CH=CHCO₂R⁹; CH=CHCONR⁷R⁸; CH₂CH₂CO₂R⁹; CH₂CH₂CONR⁷R⁸; SO₂NR⁷R⁸; SO₂NH(CH₂)_nNR⁷R⁸ or imidazolyl;

R⁵ and R⁶ are each independently H or C₁-C₄ alkyl;
 R⁷ and R⁸ are each independently H or C₁-C₄ alkyl;
 or, together with the nitrogen atom to which they are
 5 attached, form a pyrrolidino, piperidino, morpholino
 | or 4-(NR¹⁰)-1-piperazinyl group wherein any of said
 groups is unsubstituted or substituted with CONR⁵R⁶;

R⁹ is H or C₁-C₄ alkyl;

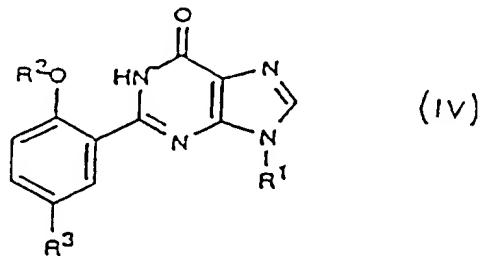
R¹⁰ is H; C₁-C₃ alkyl or (hydroxy)C₂-C₃ alkyl; and

10 n is 2, 3 or 4;

with the proviso that R⁴ is not H when R¹ is H, C₁-C₄ alkyl or
 C₁-C₄ alkoxy;

a compound of formula (IV):

15



wherein R¹ is C₁-C₄ alkyl;

R² is C₂-C₄ alkyl;

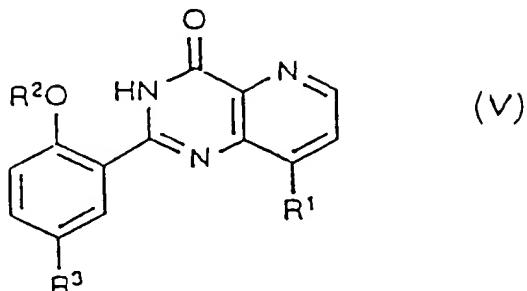
20 R³ is H or SO₂NR⁴R⁵;

R⁴ and R⁵ together with the nitrogen atom to which
 they are attached form a pyrrolidino, piperidino,
 morpholino or 4-(NR⁶)-1-piperazinyl group; and

R⁶ is H or C₁-C₃ alkyl;

or a compound of formula (V):

5



wherein R¹ is H; C₁-C₄ alkyl; CN or CONR⁴R⁵;

R² is C₂-C₄ alkyl;

10 R³ is SO₂NR⁶R⁷; NO₂; NH₂; NHCOR⁸; NHSO₂R⁸ or
N(SO₂R⁸)₂;

R⁴ and R⁵ are each independently selected from H and C₁-C₄ alkyl;

15 R⁶ and R⁷ are each independently selected from H and C₁-C₄ alkyl unsubstituted or substituted with CO₂R⁹, OH, pyridyl, 5-isoxazolin-3-only, morpholino or 1-imidazolidin-2-only; or, together with the nitrogen atom to which they are attached, form a pyrrolidino, piperidino, morpholino, 1-pyrazolyl or 4-(NR¹⁰)-1-piperazinyl group wherein any of said groups is unsubstituted or substituted with one or two substituents selected from C₁-C₄ alkyl, CO₂R⁹, NH₂ and OH;

20 R⁸ is C₁-C₄ alkyl or pyridyl;

R⁹ is H or C₁-C₄ alkyl; and

R¹⁰ is H; C₁-C₄ alkyl or (hydroxy)C₂-C₃ alkyl;

or a pharmaceutically acceptable salt thereof, or a
5 pharmaceutical composition containing either entity, for the
manufacture of a medicament for the curative or prophylactic
treatment of erectile dysfunction in a male animal, including
man.

2. The use according to claim 1 wherein in a compound of
10 formula (I) R³ is H; methyl or ethyl; R⁴ is C₁-C₆ alkyl
unsubstituted or substituted with cyclohexyl or with
morpholino; and R¹ and R² are as previously defined in claim 1;
in a compound of formula (II) R¹ is n-propyl; R² is H or
methyl; R³ is ethyl or n-propyl; R⁴ is H; ethyl substituted
15 with CONR⁵R⁶ or CO₂R⁷; vinyl substituted with CONR⁵R⁶ or CO₂R⁷;
acetyl substituted with NR⁵R⁶; SO₂NR⁵R⁶; CONR⁵R⁶; CO₂R⁷ or
bromo; R⁵ and R⁶ together with the nitrogen atom to which they
are attached form a morpholino, 4-(NR⁸)-1-piperazinyl or 2,4-
dimethyl-1-imidazolyl group; R⁷ is H or t-butyl; and R⁸ is
20 methyl or 2-hydroxyethyl; in a compound of formula (III) R¹ is
H; methyl; methoxy or CONR⁵R⁶; R² is H or methyl; R³ is ethyl
or n-propyl; R⁴ is H; acetyl unsubstituted or substituted with
NR⁷R⁸; hydroxyethyl substituted with NR⁷R⁸; CH=CHCO₂R⁹;
CH=CHCONR⁷R⁸; CH₂CH₂CO₂R⁹; SO₂NR⁷R⁸; SO₂NH(CH₂)₃NR⁷R⁸ or 1-
25 imidazolyl; R⁵ and R⁶ are each independently H or ethyl; R⁷ and
R⁸ together with the nitrogen atom to which they are attached
form a piperidino, 4-carbamoylpiperidino, morpholino or 4-

(NR¹⁰)-1-piperazinyl group; R⁹ is H or t-butyl; and R¹⁰ is H; methyl or 2-hydroxyethyl; with the proviso that R⁴ is not H when R¹ is H, methyl or methoxy; in a compound of formula (IV) 5 R¹ and R² are each independently ethyl or n-propyl; R⁴ and R⁵ together with the nitrogen atom to which they are attached form a 4-(NR⁶)-1-piperazinyl group; and R³ and R⁶ are as previously defined in claim 1; and in a compound of formula (V) R¹ is H; n-propyl; CN or CONH₂; R² is ethyl; R³ is SO₂NR⁶R⁷; NO₂; NH₂; 10 NHCOCH(CH₃)₂; NHSO₂CH(CH₃)₂; NHSO₂(3-pyridyl) or N[SO₂(3-pyridyl)]₂; R⁶ is H, methyl or 2-hydroxyethyl; R⁷ is methyl unsubstituted or substituted with 2-pyridyl or 5-isoxazolin-3-only; or ethyl 2-substituted with OH, CO₂CH₂CH₃, morpholino or 1-imidazolidin-2-onyl; or R⁶ and R⁷ together with the nitrogen 15 atom to which they are attached form a (4-CO₂R⁹)piperidino, 5-amino-3-hydroxy-1-pyrazolyl or 4-(NR¹⁰)-1-piperazinyl group; R⁹ is H or ethyl; and R¹⁰ is H, methyl or 2-hydroxyethyl.

3. The use according to claim 2 wherein in a compound of formula (III) R¹ is methyl; CONH₂ or CONHCH₂CH₃; R² is H; R³ is 20 ethyl or n-propyl; R⁴ is H; acetyl; 1-hydroxy-2-(NR⁷R⁸)ethyl; CH=CHCO₂C(CH₃)₃; CH=CHCONR⁷R⁸; SO₂NR⁷R⁸ or 1-imidazolyl; R⁷ and R⁸ together with the nitrogen atom to which they are attached form a 4-(NR¹⁰)-1-piperazinyl group; and R¹⁰ is methyl or 2-hydroxyethyl; with the proviso that R⁴ is not H when R¹ is 25 methyl; in a compound of formula (IV) R¹ is n-propyl; R² is ethyl; and R³ is 1-piperazinylsulphonyl or 4-methyl-1-piperazinylsulphonyl; and in a compound of formula (V) R¹ is n-propyl or CN; R² is ethyl; R³ is SO₂NR⁶R⁷; NHSO₂CH(CH₃)₂;

NHSO₂(3-pyridyl) or N[SO₂(3-pyridyl)]₂; R⁶ is H or methyl; R⁷ is methyl, or ethyl 2-substituted with CO₂CH₂CH₃; morpholino or 1-imidazolidin-2-only; or R⁶ and R⁷ together with the nitrogen atom to which they are attached form a (4-CO₂R⁹)piperidino or 4-(NR¹⁰)-1-piperazinyl group; R⁹ is H or ethyl; and R¹⁰ is H, methyl or 2-hydroxyethyl.

4. The use according to claim 2 or claim 3 wherein the compound of formula (I), (II), (III), (IV), or (V) is selected from

1-ethyl-5-[5-(n-hexylsulphamoyl)-2-n-propoxy-phenyl]-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

1-ethyl-5-(5-diethylsulphamoyl-2-n-propoxy-phenyl)-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

5-[5-(N-cyclohexylmethyl-N-methylsulphamoyl)-2-n-propoxyphenyl]-1-ethyl-3-methyl-1,6-dihydro-7H-pyrazolo[4,3-d]pyrimidin-7-one;

6-(5-bromo-2-n-propoxyphenyl)-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

3-methyl-6-(5-morpholinosulphonyl-2-n-propoxyphenyl)-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

6-[5-(2-carboxyvinyl)-2-n-propoxyphenyl]-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

6-[5-(2-t-butoxycarbonylvinyl)-2-n-propoxyphenyl]-3-methyl-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

3-methyl-6-[5-(2-morpholinocarbonylvinyl)-2-n-propoxyphenyl]-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

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3-methyl-6-[5-(2-morpholinocarbonylethyl)-2-n-propoxyphenyl]-1-n-propyl-1,5-dihydro-4H-pyrazolo[3,4-d]pyrimidin-4-one;

5 2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinyl-sulphonyl]phenyl}-8-methylquinazolin-4-(3H)-one;

2-{5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]-2-n-propoxyphenyl}-8-methylquinazolin-4(3H)-one;

8-methyl-2-{5-[2-(4-methyl-1-piperazinylcarbonyl)-ethenyl]-2-n-propoxyphenyl}quinazolin-4(3H)-one;

10 8-carbamoyl-2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinylsulphonyl]phenyl}quinazolin-4(3H)-one;

8-ethylcarbamoyl-2-(2-n-propoxyphenyl)quinazolin-4(3H)-one;

2-[2-ethoxy-5-(4-ethoxycarbonylpiperidino-sulphonyl)phenyl]-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

15 2-[5-(4-carboxypiperidinosulphonyl)-2-ethoxyphenyl]-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

2-{2-ethoxy-5-[4-(2-hydroxyethyl)-1-piperazinyl-sulphonyl]phenyl}-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one;

20 and

2-{2-ethoxy-5-[(bis-3-pyridylsulphonyl)amino]-phenyl}-8-n-propylpyrido[3,2-d]pyrimidin-4(3H)-one.

5. A pharmaceutical composition for the curative or prophylactic treatment of erectile dysfunction in a male animal, including man, comprising a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to 25 4, or a pharmaceutically acceptable salt thereof together with a pharmaceutically acceptable diluent or carrier.

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6. The use of a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to 4, or a pharmaceutically acceptable salt thereof for the curative or prophylactic treatment of erectile dysfunction.

5 7. The use of a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to 4, or a pharmaceutically acceptable salt thereof, or a pharmaceutical composition containing either entity, for the manufacture of a medicament for the curative or prophylactic treatment of female
10 sexual dysfunction, premature labour or dysmenorrhea.

8. The use of a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to 4, or a pharmaceutically acceptable salt thereof for the curative or prophylactic treatment of female sexual dysfunction, premature
15 labour or dysmenorrhea.

9. A pharmaceutical composition for the curative or prophylactic treatment of female sexual dysfunction, premature labour or dysmenorrhea comprising a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to
20 4, or a pharmaceutically acceptable salt thereof, together with a pharmaceutically acceptable diluent or carrier.

10. A commercial package comprising a compound of formula (I), (II), (III), (IV) or (V) as defined in any one of claims 1 to 4, or a pharmaceutically acceptable salt thereof, together
25 with instructions for its use in the curative or prophylactic treatment of female sexual dysfunction, premature labour or dysmenorrhea.

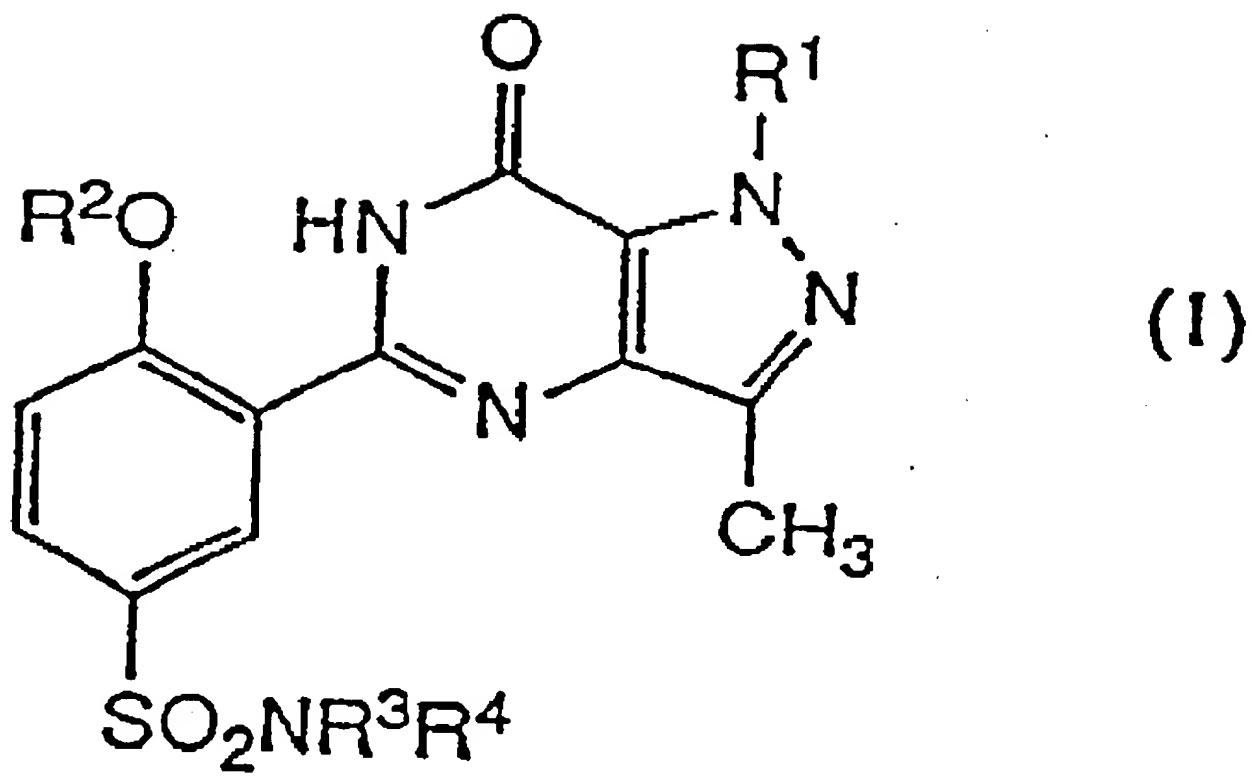
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11. A commercial package comprising a compound of formula
(I), (II), (III), (IV) or (V) as defined in any one of claims 1
to 4, or a pharmaceutically acceptable salt thereof, together
with instructions for its use in the curative or prophylactic
5 treatment of erectile dysfunction.

SMART & BIGGAR
OTTAWA, CANADA

PATENT AGENTS



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